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(19)(CA) # CANADIAN PATENT

(54) DISPOSABLE ABSORBENT ARTICLES

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This invention relates to disposable articles and more particularly relates to disposable absorbent articles such as diapers, incontinency pads and the like.

The use of disposable absorbent articles of the kind mentioned above has greatly increased in recent years due to their ease of use, low cost and the obvious sanitary value of having a clean, fresh, disposable absorbent article for use without the inconvenience of having to wash and reuse a previously used nondisposable article. The advantages of using disposable absorbent articles are particularly apparent in the widespread acceptance of disposable diapers as a replacement for the cloth diapers which have traditionally been used.

In addition to the advantages set forth above for disposable absorbent articles many of these articles include, as an integral part of their structure, a liquid impermeable backing sheet which offers other advantages in use. For example, disposable diapers which include such a backing sheet obviate the necessity of using rubber pants on the baby to prevent leakage through the diaper and consequently wetting of the baby's clothing.

The present invention will be described in detail with reference to a disposable diaper, but it will be obvious to those skilled in the art that the teachings are applicable to other disposable absorbent articles such as incontinency pads and the like.

In its most fundamental construction a disposable diaper merely comprises a layer of disposable absorbent material lining a backing sheet f liquid impermeable material

which may be disposable or reusable. The thickness of the layer of absorbent material can b varied depending upon the desired use. For example, if the diaper were to be used overnight or for an older baby it would be required to have a greater absorptive capacity than one used for a short time during the day or for an infant and consequently the absorbent layer would be thicker. The length and width of the diaper can also be varied for different size babies. Generally, the absorbent pad will be about 1/8 to 1/2 inch thick and the diaper will have a length of about 12 to 18 inches and a width of about 8 to 16 inches.

While a baby diaper constructed in this manner supplies the essential ingredients of a disposable diaper, namely an absorbent layer and a liquid impermeable backing sheet, modifications have previously been proposed to overcome one or more of the defects inherent in the basic construction. It was found, for example, that when the absorbent layer became soaked with urine it tended to wad together or lost most of its integral strength and began to shread.

In order to overcome these disadvantages it has been common to place a layer of non-woven, gauze, or other material which will maintain its integrity after wetting on top of the absorbent layer of the diaper thereby sandwiching the absorbent layer between a topsheet of self-supporting but liquid permeable material and a backing sheet of liquid impermeable material. Such a construction overcame the disadvantages of shreading but tended to make the baby uncomfortable after wetting since

the urine would partially be absorbed by the topsheet which was against the skin of the baby. This contact of the baby's skin with urine on the surface of the diaper is one of the principal causes of diaper-derived skin rash. Additionally, upon removal of a wet diaper, it was found that the baby's skin was wet and drying was necessary before a clean diaper could be applied.

In an attempt to overcome this dificiency it has been suggested that the topsheet be made hydrophobic or water-shedding to maintain the layer which is in contact with the baby's skin as dry as possible. This has been accomplished by forming the topsheet of the diaper in part or completely of hydrophobic fibers or by coating or impregnating an otherwise hydrophilic topsheet with a hydrophobic resin.

This procedure has not been completely satisfactory since the topsheet of the diaper, whether it be a woven or nonwoven material, will contain spaces between its fibers which are continually open to the passage of liquid in both directions. The spaces are necessary to allow urine to pass from the baby to the absorbent layer of the diaper. When the diaper has reached its maximum capacity or when pressure is applied to the absorbent layer, for example by the baby sitting in the wet diaper, the absorbent layer acts much like a sponge which has been fully saturated or compressed and exudes urine to its surface where it can pass through the openings in the topsheet and contact the skin of the baby.

It is an object of this invention to provide a disposable absorbent article, such as a disposable diaper, having a topsheet which will readily permit flow of liquid in the direction of the absorbent layer but which substantially reduces the possibility of flow in the opposite direction. This and other objects will readily become apparent to those skilled in the art in light of the teachings herein set forth.

In its broad aspect, the disposable absorbent articles of this invention are comprised of, in combination, at least one absorbent pad and a topsheet adjacent to said pad and having a plurality of valvular openings therein. The topsheet is preferably formed from a non-fibrous hydrophobic film such as thermoplastic film having a plurality of valvular apertures therein.

One embodiment of the invention will be described in detail with reference to the accompanying drawing which is merely illustrative and is not intended, in any manner, to limit the scope of the invention.

The accompanying drawing is a plan view, partially cut away, of a preferred disposable diaper.

Referring in detail to the drawing there is shown a disposable diaper, generally designated 10, comprising a rectangular absorbent pad 12 substantially centrally located and sandwiched between a thin, flexible backing sheet 14 of liquid impermeable material, such as polyethylene film, and a thin flexible topsheet 16 also of a normally liquid impermeable material. Topsheet 16

example, as an overnight diaper, it may be desired to have a thicker and more absorbent pad and a thickness of about 1/4 inch, using about 10 to 20 layers of wadding, would usually be sufficient.

Absorbent materials other than tissue and wadding will of course be useful in the diaper construction of the present invention. For example, absorbent non-woven pads can be fabricated to any desired thickness and substituted for the absorbent pads described above. One such absorbent pad which has been used extensively in disposable diapers is a wood pulp product commonly known as wood fluff and is prepared in the same manner as a non-woven fabric.

The only criteria for utility in the present invention are that the material be absorbent, be capable of being fabricated in the form of a pad, be compatible with the waste products with which it will come in contact and be non-irritating to the skin.

Various natural and synthetic polymeric materials are themselves absorbent or can be made absorbent and will therefore be useful as, or in combination with, the absorbent pad of the present invention. One group of polymers which are particularly preferred are insoluble hydrophilic homopolymers and copolymers which form a gel upon absorption of water. These materials offer the obvious advantage of holding tenaciously to liquid and preventing the release of liquid from the absorbent article and leaking or wetting skin or clothing with which the absorbent article is in contact.

has a plurality of slits 18 therein which slits will be described in greater detail hereinafter.

Backing sheet 14 and topsheet 16 are of approximately equal size and are of a length and width slightly greater than the corresponding dimensions of absorbent pad 12. The edges of backing sheet 14 and topsheet 16 are sealed to each other around the entire periphery of the diaper and just outside the outermost edges of absorbent pad 12. The sealing can be accomplished by any convenient means, such as the use of an adhesive, but heat sealing is preferred and is indicated by heat seal 20 around the periphery of the diaper.

The absorbent pad 12 is a plurality of layers of absorbent tissue paper or wadding stacked to the desired thickness. The wadding layers need not be adhered to each other but, since it has been common practice to adhesively, mechanically, or otherwise secure the layers to each other to maintain the relative position of the layers and the shape of the absorbent pad, such can also be done in the diaper of the present invention. The wadding can be stacked to form a pad of any desired thickness and hence absorbency can be controlled for any particular use. For example, in conventional disposable diaper constructions designed for use during the day it has been common to stack the absorbent wadding to a thickness of about 1/8 inch using generally from about 5 to 10 layers of wadding. For special uses, for

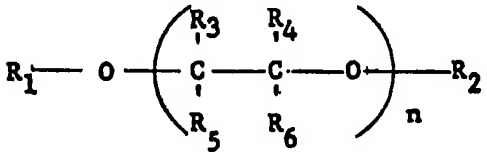
In practice, the materials which have been found particularly useful are insoluble hydrophilic polymers prepared from the following starting materials: poly(alkylene oxides), e.g. poly(ethylene oxide), polyvinyl alcohol, polyvinylmethyl ether, copolymers of maleic anhydride and ethylene, copolymers of maleic anhydride and vinylmethyl ether, polyelectrolytes, etc.

Insoluble hydrophilic polymers, sometimes referred to as "hydrogels", are especially useful in the present invention because they possess the ability to consume very large amounts of water in the order of 25 to 100 times their dry weight.

The term "insoluble" or "insolubilization" as employed in relation to these polymers is intended to define the formation of a gel which does not flow and does not expel water under the pressures encountered in the use of products described above.

The insolubilization can be effected by a wide variety of methods and includes, but is not limited to, ionizing and nonionizing radiation and chemical cross-linking through covalent and ionic bonding.

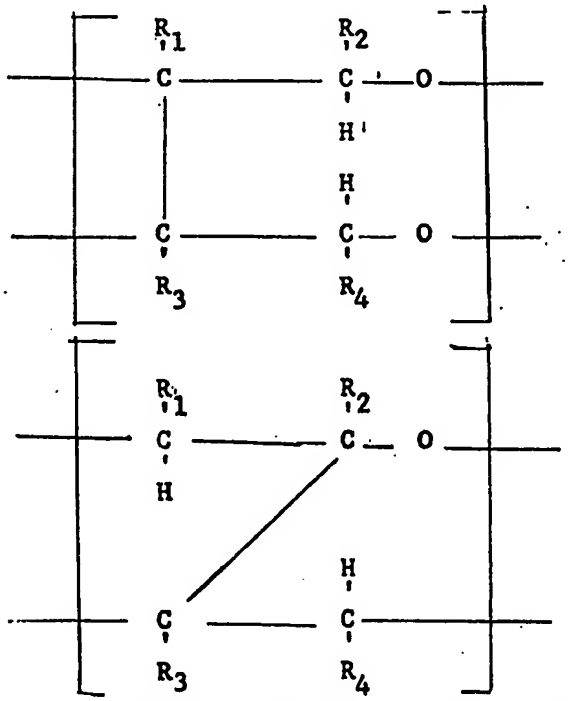
A particularly preferred hydrogel for use in the articles of this invention is comprised of at least one hydrophilic polymer of the formula



which has been cross-linked and wherein R_1 and R_2 are

selected from the group consisting of hydrogen, alkyl radicals and alkyl substituted aryl radicals, and wherein R_3-R_6 are selected from the group consisting of hydrogen, methyl, phenyl and vinyl radicals, and n is greater than one.

The hydrogels are polymeric compounds containing at least one of the structural units shown below:



wherein R_1-R_4 are selected from the group consisting of hydrogen, methyl, phenyl and vinyl radicals.

These hydrophilic polymers may include carbon-to-carbon cross-linking between straight chain carbon atoms and the carbon atoms of branch chain methyl groups and in addition a very minor and insignificant number of bonds may include two oxygen atoms linking the carbon atoms.

The polymeric gel compounds may contain cross-

linking bonds present as inter-molecular bonds (e.g. between two different molecules) and intramolecular bonds (e.g. between carbon atoms of the same molecule), and combinations of intra and intermolecular cross-linking bonds.

The hydrogels can be used in the diaper constructions of the present invention either in the form of thin transparent sheets disposed between or in place of wadding layers of the absorbent pad or can be embedded in the fibers of the absorbent pad as a powder or in shredded form. The manner in which the materials are incorporated into the pad is not critical since it is merely necessary to have the polymers come in contact with the liquid which penetrates the topsheet of the absorbent article.

The materials used in the fabrication of the topsheet and backing sheet of the absorbent articles of the present invention are also not limited to any particular chemical compositions since it is their physical properties rather than their chemical properties which are important in the articles of the invention. These materials should, of course, be thin, flexible, self-supporting, and substantially water impermeable films. Preferably they are thermoplastic materials which are capable of being heat sealed to each other.

The backing sheet is preferably an olefinic or vinyl film. Polyethylene of a thickness of from about 0.4 to about 1.5 mils is most preferred. This type of film has previously been used extensively for this purpose and commonly has had an embossed d sign in its

surface to simulate the appearance and hand of cloth. These manufacturing techniques will also find use in the absorbent articles of the present invention.

Any film which is useful as a backing sheet will also be useful as a topsheet for the disposable absorbent articles of the invention. It is preferable, however, to use a film for the topsheet which resembles cloth more closely in feel and appearance since it is this portion of the article which will come in contact with the skin of the user. One film which has been found particularly useful is ethylene-ethyl acrylate film. This copolymer is cloth-like, softer and stronger after slitting than polyethylene film. The film should have a thickness of from about 0.4 to about 2.0 mils with about 1.0 to 1.5 mils being preferred.

As described above, the topsheet is made from a substantially liquid impermeable film and must be provided with valvular openings to be effective in the absorbent articles of the present invention.

The term "valvular" as used throughout the specification and in the claims is intended to refer to apertures in the topsheet which are capable of opening to permit passage of liquid under certain circumstances and reclosing to retard passage of liquid under certain other circumstances. When open, the valvular openings should have the ability to pass at least 20 milliliters of liquid within 10 seconds when an area of about 20 square inches is wett d. These openings may be of two basic types, substantially straight slits and

punctures.

The slits useful in the present invention must be substantially straight since, if they are curved, V-shaped or of any other configuration, they will form flaps in the surface of the film which are too easily opened and tend to remain open. Such slits, while permitting sufficient passage of liquid in the direction of the absorbent pad, do not act to substantially reduce backflow of liquid, which is the primary object of the present invention. This disadvantage is also present if holes are formed in the film by removing pieces of film material as opposed to puncturing the film without removal of film material. The film is thereby left open to the uncontrolled passage of liquid in both directions.

It has previously been suggested (see U. S. Patent No. 2,877,765 and U. S. Patent No. 3,399,672) to incorporate curved slits in the layer of a surgical dressing or bandage which is applied adjacent to the skin to permit easy removal of the dressing from the skin. It was found, however, for that particular use, that straight-sided slits were inoperative. Conversely, it has now been found that, while straight-sided slits perform excellently and unexpectedly in topsheets for disposable diapers, curved slits are unsuitable for such use. This disparity in the performance of straight versus curved slits can probably best be explained by the different functions to be preformed by the slits in each application.

In surgical dressings, for example, the topsheet must be p rmeable to liquid draining from a wound usually slowly ov r a long period of time. Backflow

from the dressing is not a problem since the absorbent layer has ample time to distribute the liquid by wicking and no pool of liquid is formed at the interface between the absorbent layer and the topsheet.

In a disposable diaper a quite different method of operation is encountered. Rather than a slow steady flow, before bladder control is obtained, babies urinate from 5 to as many as 30 or 40 times a day and average about 10 times a day with about 40 grams of urine per urination. There are, therefore, intermittent floods of liquid contacting the topsheet of the diaper. The topsheet must quickly pass this liquid through to the absorbent layer and prevent backflow to a degree sufficient to permit the liquid to be absorbed. This task becomes increasingly more difficult after the second and subsequent urinations since the absorptive capacity of the absorbent layers is substantially reduced. In addition, as a baby sits in a wet diaper it releases liquid to the surface of the absorbent pad where it will pass through the topsheet and contact the baby's skin unless the openings in the topsheet act to prevent this backflow.

As will be demonstrated hereinafter, curved slits permit adequate drainage of liquid in the direction of the absorbent layer but do not prevent backflow to a degree sufficient to allow their use in an improved construction.

The appended drawing shows a preferred topsheet construction wherein the topsheet 16 contains a plurality of straight slits 18 arranged in staggered parallel rows along the surface of the topsheet. This construction is

preferred since it yields a topsheet which is strong and yet permits maximum passage of liquid.

To be efficient, the topsheet should contain from about 10 to 1000 valvular openings per square inch of film. When slits are used, they should each be from about 0.030 to about 0.5 inch in length. Preferably there are from about 30 to about 150 slits per square inch, each of such slits being from about 0.07 to about 0.2 inch in length. The most preferred film contains about 50 slits per square inch, each about 0.1 inch in length.

The slits enable the topsheet of the absorbent article to act as a kind of one-way valve to the flow of liquid. For example, in the case of a disposable diaper, the motion of the baby within the diaper, such as by walking or sitting, will cause the slits to open and close continually. When the baby wets, the urine will contact the topsheet of the diaper and any motion on the part of the baby will cause numerous slits to open and allow the urine to drain through to the absorbent pad below. Even without motion on the part of the baby a number of slits will be open to the passage of liquid due to the contour of the diaper around the baby's bottom. Only minimum contact of liquid with absorbent is necessary. Once contact has been made and drainage has begun, a kind of siphon action is initiated which will cause substantially all of the urine to drain through the topsheet and into the absorbent pad. After the urine has drained through the slits, the outer surface of the t psheet will be almost dry due to its hydrophobic nature.

Passage of the urine back thr ugh the slits from the absorbent pad will be retarded since there will not be a pool of liquid in contact with the underside of the topsheet to flow back through the slits as they are opened and closed by motion of the baby. An effective barrier preventing the return of the urine to contact with the skin of the baby is thereby established and the outermost portion of the topsheet which contacts the baby's skin is kept relatively dry.

The valvular openings can be formed in the topsheet in a number of ways. The easiest involves the use of a roller having a number of razor edges protruding therefrom across the width of the r>ller and around its circumference. The cutting edges can be spaced as desired on the roller and, if the portion protruding from the roller is triangular in shape, the length of the slit made in the film can be controlled by limiting the depth to which the blade pierces the film. A resilient backup roller can be provided to assist the piercing of the film which is fed between the slitting roller and the backup roller. If desired, portions of the topsheet may be retained in their unpierced condition. This might be accomplished, for example, along a strip about one inch wide around the periphery of the topsheet. Such a strip would act as an additional safeguard against leakage at the edges of the diaper which might come into direct contact with the baby's clothing.

After the topsheet is slit, the assembly of the diaper follows, more or less, conventional methods

of fabrication. Th topsheet and backing sheet are cut to approximately the same dimensions which are equal to the desired size of the final diaper. The size can be varied according to the desired use, for example, in an infant's diaper a size of 10 x 14 inches might be sufficient whereas in a diaper for a large child a size of 12 x 16 inches would be better and a size of 14 x 18 inches might be preferred for a diaper which could accommodate a toddler.

The topsheet and backing sheet are juxtaposed one on the other with the absorbent pad sandwiched therebetween in approximately the center of the sheets. The absorbent pad should be of a length and width slightly smaller than the topsheet and backing sheet to permit sealing of the topsheet to the backing sheet around their periphery. An overhang of about 1/2 inch on each side should be sufficient. Sealing can conveniently be accomplished by heat sealing the edges. The heat sealing might also be used to simultaneously accomplish a cutting of the edges to trim excess sheet material from the diaper and yield a diaper structure which is neat in its appearance.

If desired, the absorbent pad may be of the same length as the topsheet and backing sheet and the top and bottom edges of the diaper may be left unsealed. Such a construction readily lends itself to mass production techniques since the diapers can be fabricated in a continuous line and cut to the desired length without the necessity of further finishing.

It has been found that the diaper can be assembled in the manner described above before the topsheet is slit and a rotary slitter can be used to cut the valvular openings in the topsheet of the finished diaper without damage to the backing sheet or loss of its liquid impermeability.

It will b obvious to those skilled in th art that applicant has disclosed a basic diaper construction which is

adaptable to the inclusion of other materials for specific purposes. For example, it might be desired to add a perfume or deodorizer to the absorbent pad, to include baby powder or a soothing lotion on the outer surface of the topsheet, or to incorporate a germicidal agent somewhere in the diaper construction.

Moreover, it will be obvious to those skilled in the art that the above teaching, which is set forth in detail with respect to disposable baby diapers, will be equally applicable to similar disposable absorbent articles such as incontinency pads and the like. In each of these uses the construction of the absorbent article will be basically the same as that set forth for a diaper construction except that size, shape, and absorbency will be varied for the particular use. In addition, tabs, adhesives, or some other attachment means might suitably be included for the convenience of the wearer.

The following examples are merely illustrative of the present invention are not intended to be limitative thereof.

EXAMPLE 1

An absorbent pad consisting of eight layers of absorbent wadding and measuring approximately 12 inches x 16 inches x 3/16 inch was positioned in the center of a sheet of polyethylene film measuring about 12-1/4 inches x 16-1/4 inches x 1.25 mil having a taffeta design embossed therein.

A 1.25 mil thick sheet of ethylene-ethyl acrylate film was perforated by feeding it through the nip of a roller having a plurality of small blades spaced

around it circumference in staggered parallel rows and a resilient backup roller. The perforating roller had a blade density of about 125 blades per square inch and the resulting perforated film had about 125 parallel slits per square inch each measuring about 0.1 inch in length.

The perforated film was cut to approximately 12-1/4 inches x 16-1/4 inches and placed on top of the absorbent wadding pad thereby sandwiching the pad between the perforated film and the polyethylene film. The edges of the two films were then heat sealed to each other with a bar sealer to complete the assembly procedure and the resulting disposable diaper functioned satisfactorily.

EXAMPLE 2

A disposable diaper was fabricated from a backing sheet of translucent polyethylene film measuring about 12-1/4 inches x 16-1/4 inches x 1.25 mil and a top sheet of translucent ethylene-ethyl acrylate film measuring about 12-1/4 inches x 16-1/4 inches x 1.25 mil. The absorbent pad was eight layers of absorbent wadding and measured about 12 inches x 16 inches x 3/16 inch. The three layers of the diaper were assembled and heat sealed in the manner set forth in Example 1 and the completed diaper was run, topsheet side up under a rotary slitter. The blades of the slitter were set to pierce the topsheet and protrude partially into the absorbent pad but not to penetrate through the absorbent pad to contact the backing sheet. The slits formed were of the size and placement of those of Example 1 and the diaper

performed as well as the diaper of Example 1.

EXAMPLE 3

A diaper was fabricated in the manner described in Example 2 except that the absorbent pad used was formed with about 2 grams of cross-linked, powdered poly(ethylene oxide) sprinkled on 4 layers of wadding and covered with another 2 layers of wadding. The entire assembly was then used in the fabrication of the diaper.

The resulting diaper was thinner than the diaper of Example 2 yet had a greater absorptive capacity.

The following experiments were conducted to compare the performance of curved versus straight slits in the topsheet of a simulated diaper construction.

EXPERIMENT 1

A 5-3/8 inch diameter circle of test film supported on a screen and covered by a 5-3/8 inch diameter circle of absorbent was clamped between a 5-3/8 inch diameter glass cylinder and a 5 inch diameter funnel leading to a graduate. A No. 13 rubber stopper was placed on top of the test film and 200 millliliters of water was quickly added to the glass cylinder. Times were recorded when the first drop of water was collected and when 100 millliliters had been collected.

Test films having about 45-48 slits per square inch and an average slit length of 0.10 inch were tested.

When straight slits wer test d, the first drop of water was collected in 2 seconds and 100 millliliters was collected in 14 seconds. When curved slits were tested the first drop was collected in 1 second and 100 milliliters was collected in 3 seconds.

The results of this comparison indicate that both straight and curved slits performed satisfactorily in passing liquid through to an absorbent.

EXPERIMENT 2

The same glassware as in Experiment 1 was employed but the test procedure was modified to determine the backflow obtained with samples of test film identical to those of Experiment 1.

The film was placed across the top opening of the funnel such that it did not sag nor stretch open. A circle of wadding was placed over the film and the glass cylinder was clamped in place. One hundred milliliters of water was added to the cylinder and the times were recorded for collection of the first drop and 10 milliliters of water in the graduate.

The first drop through both straight slits and curved slits was collected in 1 second but curved slits collected 10 milliliters in 10 seconds whereas straight slits took 95 seconds to collect the same volume. Backflow for curved slits is therefore considerably faster than for straight slits and unsatisfactory for an improved diaper construction.

EXPERIMENT 3

Backflow was also measured for films having

curved and straight slits of the same size and quantity as the films of Experiments 1 and 2 by wetting a 5 inch diameter absorbent pad with 30 milliliters of water covering the pad with the test film and covering the film with another dry absorbent pad of known weight and a 12 pound weight. After 2 seconds the dry pad was weighed to determine water pick-up.

The average backflow for curved slits was 5.1 grams while straight slits averaged only 3.0 grams again indicating that straight slits would be more suitable for use in diaper constructions than curved slits.

As a control the experiment was also run with no film between the wet and dry pads and with a non-woven having 50 per cent open spaces between the pads. Without any film between the pads 8.9 grams of water was picked-up while with the non-woven 7.1 grams was absorbed.

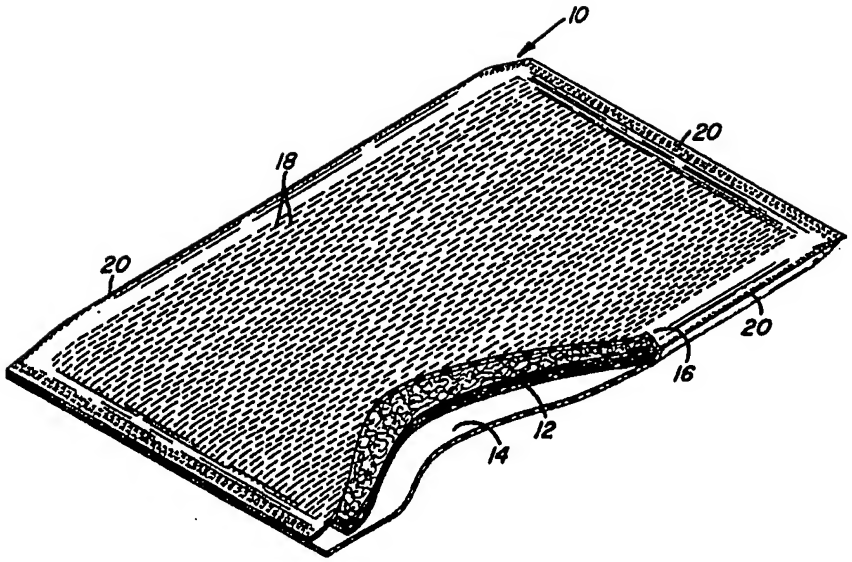
It will be obvious that while the present invention has been set forth in some detail and described with particularity, it is susceptible to changes, modifications and alterations without departing from the scope and spirit of the invention as defined in the appended claims.

WHAT IS CLAIMED IS:

1. A disposable liquid absorbent article formed from an absorbent pad, a topsheet of thin flexible material in contact with said absorbent pad for placement adjacent to the body of the user and a substantially liquid impermeable backing sheet provided adjacent to the absorbent pad on the side opposite the top sheet wherein the said topsheet is a non-fibrous hydrophobic ethylene - ethyl acrylate film 0.4 to 2.0 mil (10 to 50 microns) thick and wherein said topsheet has a plurality of valvular openings therein said valvular openings comprising 10 to 1,000 slits per square inch (1.5 to 150 per sq. cm.) of film each of such slits being substantially straight and from 0.030 to 0.5 inch (0.07 to 1.3 cm.) in length said openings being substantially closable to prevent contact of said absorbent material with the body and to retard backflow of liquid from said absorbent pad and wherein said absorbent pad includes an absorbent polymeric hydrogel.

2. An article as claimed in Claim 1 wherein said slits are 0.050 to 0.5 inch (0.13 to 1.3 cm.) in length.

3. An article as claimed in Claim 1 or 2 wherein said absorbent polymeric hydrogel is a cross-linked poly (ethylene oxide).



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